APPENDIX L: **VARIABLE DISCHARGE FLOOD CONTROL**

Description and Development of VARQ

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Introduction

Prior to Endangered Species Act listings of a variety of fish species in the Columbia River Basin, the Corps operated Libby Dam using Standard Flood Control (FC). Under Standard FC, the dams would generally draft deeply during the January-April period to provide water storage for flood control. Then, during refill, dam discharges would be held at minimum flows.

Since the early 1990s, Columbia River water management has changed due to the Endangered Species Act and the listing of various species of fish (Columbia and Snake River salmon, Kootenai River white sturgeon, and Columbia Basin bull trout) as threatened or endangered. As part of efforts to conserve and recover the listed fish species, the Corps releases water from Columbia Basin dams for flow augmentation. Libby Dam provides flow augmentation for white sturgeon in the spring, minimum flows for bull trout during the spring and summer, and flow augmentation for salmon in the spring and summer. These fish flow releases exceed the minimum flows envisioned in the Standard FC plan and have reduced the likelihood and frequency of refill at the project.

Design of Variable Discharge Flood Control (VARQ)

With the objective of better assuring reservoir refill while providing fish flows, the Corps in coordination with the state of Montana, NOAA Fisheries and USFWS developed variable discharge (or VARQ, with Q representing engineering shorthand for discharge) flood control (FC) from the late 1980s. VARQ FC is intended to improve the multi-purpose operation of Libby Dam and Hungry Horse dams while not reducing the level of flood protection in the Kootenai, Flathead and Columbia River systems.

The Standard flood control storage reservation diagram (SRD) was based on the concept that outflows from Libby during the refill period would be held at their minimum discharge of 4,000 cfs. In contrast, VARQ FC was designed to allow outflows to vary during refill and be higher than minimum outflows based on the water supply forecast. This allows Lake Koocanusa to be at higher elevations during the winter, and increases refill reliability. Operating to VARQ FC has the potential to more reliably supply spring and summer flows for fish.

Compared to Standard FC, VARQ FC provides less flood control space at Libby and Hungry Horse dams prior to spring runoff. The flood control space needed in a given year varies based on each dam's seasonal water supply forecast (WSF), and is adjusted at least monthly during the runoff season for that year. In years where the April through August seasonal WSF is within the range of 80 and 120 percent[1] of average at Libby Dam, the VARQ FC reservoir elevation would

[1] For forecasts greater than 120 percent of average, Libby Dam may not able to draft to either VARQ FC or Standard FC reservoir elevation targets during the winter and early spring because outflows must be reduced to comply with the IJC Order of 1938 concerning Kootenay Lake levels.

be higher than the Standard FC reservoir elevation during the January through April drawdown period. In years where the seasonal water supply forecast is high (above about 120 percent of the average volume at Libby Dam), storage space for flood control would be the same for either VARQ FC or Standard FC.

The amount of storage space needed in the project for flood control can be reduced without compromising system flood control if water that would be stored during the refill period (under Standard FC) is instead passed through the project. Accordingly, in years where the water supply forecasts at Libby are expected to be about 80% to 120% of average, the VARQ FC outflow during refill may be greater than minimum flows during the refill period of April through July. In years where the seasonal runoff forecast is high (above 120% of the average volume at Libby), VARQ FC storage space for flood control and outflows during refill are the same as Standard FC.

VARQ was first introduced as a possible alternative in the *Columbia River System Operation Review Environmental Impact Statement, November 1995 (SOR EIS- BPA et al 1995)*. The SOR EIS addressed operation of the 14 major Federal Columbia River Power System (FCRPS) dams. Although the SOR was being planned for other reasons before the first petitions for listing of salmon were filed in 1990, the preferred alternative ultimately included operations that were recommended by the FCRPS Biological Opinions issued by the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) in 1995. VARQ FC was among many early screening alternatives in the SOR EIS, but was not carried forward among the final set of alternatives analyzed. However, evaluation of VARQ FC was included in the measures recommended for Libby and Hungry Horse dams in 1995 FCRPS Biological Opinion by the USFWS. A more detailed, system-level analysis of VARQ FC was conducted for the *Columbia River Basin System Flood Control Review* (Corps 1997). Results of both these evaluations indicated that more work was needed to identify the impacts to providing local flood protection for the Kootenai River. This work was completed in *Kootenai River Flood Control Study, Analysis of Local Impacts of the Proposed VARQ Flood Control Plan* (McGrane 1997) and *Status Report: Work To Date On The Development Of The Varq Flood Control Operation At Libby Dam And Hungry Horse Dam* (Corps 1999).

Historical Background of VARQ Flood Control

In the late 1980s, the Montana Department of Fish, Wildlife, and Parks (MFWP) developed an alternative operation strategy called Biological Rule Curves (BRCs) for Libby and Hungry Horse dams to enhance biological production in the reservoirs. In the early 1990s, MFWP refined the BRCs to focus on aquatic productivity upstream and downstream of the dams. Subsequently, the BRCs were integrated with power production and system flood control to generate the Integrated Rule Curves (IRCs) that more fully considered the multiple purposes of Libby and Hungry Horse dam operations in the context of local and system effects. The IRCs were essentially multipurpose refinements of the BRCs. In the IRCs, local flood control was a priority on project operations; if flood conditions developed at Bonners Ferry(for Libby) or Columbia Falls (for

Hungry Horse), the IRCs assumed that the dams would reduce water releases to the extent possible (Marotz et al. 1996).

The Corps first introduced VARQ FC as a possible operational alternative for Libby and Hungry Horse dams in the SOR EIS process (BPA et al. 1995). The SOR Flood Control Work Group concluded that the VARQ FC procedure had promise and further refinements could lead to its implementation; however, VARQ FC was not among the final alternatives analyzed in the SOR EIS. The Corps, with input from MFWP, subsequently evaluated and refined VARQ FC and its potential impacts and benefits in a series of reports in the late 1990s (Corps 1997; McGrane 1997; Corps 1999). Additional analysis of VARQ FC is contained in the Upper Columbia Alternative Flood Control and Fish Operations Final EIS (Final UCEIS; Corps 2006).

Current Status of VARQ FC at Libby Dam

On December 31, 2002, the Northwestern Division Commander signed a Finding implementing VARQ at Libby Dam on an interim basis. This Finding was based on a Decision Document on Upper Columiba River Alternative Flood Control and Fish Operations Interim Implementation dated December 2002, and a Finding of No Significant Impact (FONSI) following an Environmental Assessment (EA) on the potential impacts of interim VARQ implementation. The Final EA and FONSI are online at http://www.nws.usace.army.mil/ers/Doc_Table.cfm?status=1 (Project - Upper Columbia Alternative Flood Control and Fish Operations). The decision was to implement interim VARQ until completion of the EIS process for long-term Libby Dam operations.

Potential alternatives for long-term operations are evaluated in the Final UCEIS which was released in April 2006 just prior to the 2006 Kootenai River spring run-off event. The Corps has not yet issued a Record of Decision on long-term Libby Dam operations.

Observations and findings concerning Libby operations in 2006, as discussed in this after-action report, will help guide decisions on future Libby Dam operations. With regard to decisions on Libby Dam operations over the long term, the Corps analysis will consider potential updates or modifications of Libby Dam operation alternatives to more realistically reflect actual Libby Dam operations, and additional analysis of potential impacts in consideration of observations in 2006 and other VARQ FC years. Data gathering, analysis of the data, and stakeholder coordination of any updated analyses will likely result in a decision on long-term Libby Dam operations in the spring of 2007, at the earliest.

In the more immediate term, the Corps must incorporate lessons learned in 2006 and previous VARQ FC years into plans for Libby Dam operations during the 2007 flood control season. The Corps must make a decision on Libby operations during the 2007 water year by early December 2006. For this short-term decision, the Corps will consider the best available information on impacts from 2006 operations and analysis of past VARQ implementation to decide on a 2007 operation that considers flood damage reduction, flow augmentation for fish, hydropower production, and the many other multiple purposes of the project.

VARQ FC Operating Procedures at Libby Dam

VARQ FC affects Libby Dam operations primarily during the January through July flood control season. This period of interest can be broken into 2 main parts: the draft period (Janaury through approximately April) and the refill period (approximately April through July).

During the winter, the water level in the reservoir is drawn down or drafted based on the April-August seasonal water supply forecast (WSF). The higher the WSF, the deeper the reservoir draft. The amount of draft is determined by the storage reservation diagram (SRD) that is developed for the specific flood control strategy, in this case VARQ FC.

Refill of Libby Dam may commence in the spring 10 days before unregulated flow on the Columbia River at The Dalles, Oregon, is forecasted to reach that year's initial controlled flow (ICF).[2] At the start of the refill period, VARQ Refill Guidance is calculated using the April-August WSF, the duration of the refill period, and the current reservoir elevation. In subsequent calculations, adjustments are made to compensate for previous dam outflows that may have been higher or lower than the outflow that had previously been calculated, and WSF based on the most recent information.

Rules that govern the VARQ FC at Libby Dam during the draft and refill period are broken down into the steps on the following pages.

[2] The first controlled flow of the runoff season is called the Initial Controlled flow (ICF). The ICF, the first, or initial, controlled flow of the runoff season to which control will be attempted for the Columbia River as measured at The Dalles, Oregon. The Initial Control Flow is used in conjunction with unregulated streamflow forecasts to guide the determination of when to begin refill of reservoirs.

VARQ Operating Procedures at Libby Dam

INTRODUCTION. The following pages contain a description of the rules that govern the VARQ FC procedure at Libby Dam. The general rules are listed below.

Rule 1. Storage Reservation Diagram. A storage reservation diagram (SRD) for Libby Dam (see figure below) guides the evacuation of space for flood control. Required space is a function of the April-August runoff volume forecast at Libby Dam. Following the evacuation period, the project is required to maintain this space until the initiation of refill. During evacuation and up until the initiation of refill, outflows should be limited to hydraulic capacity of the powerhouse to the best extent possible. However, situations such as the loss of hydraulic capacity or rapidly changing forecasts may require spill to meet flood control requirements.

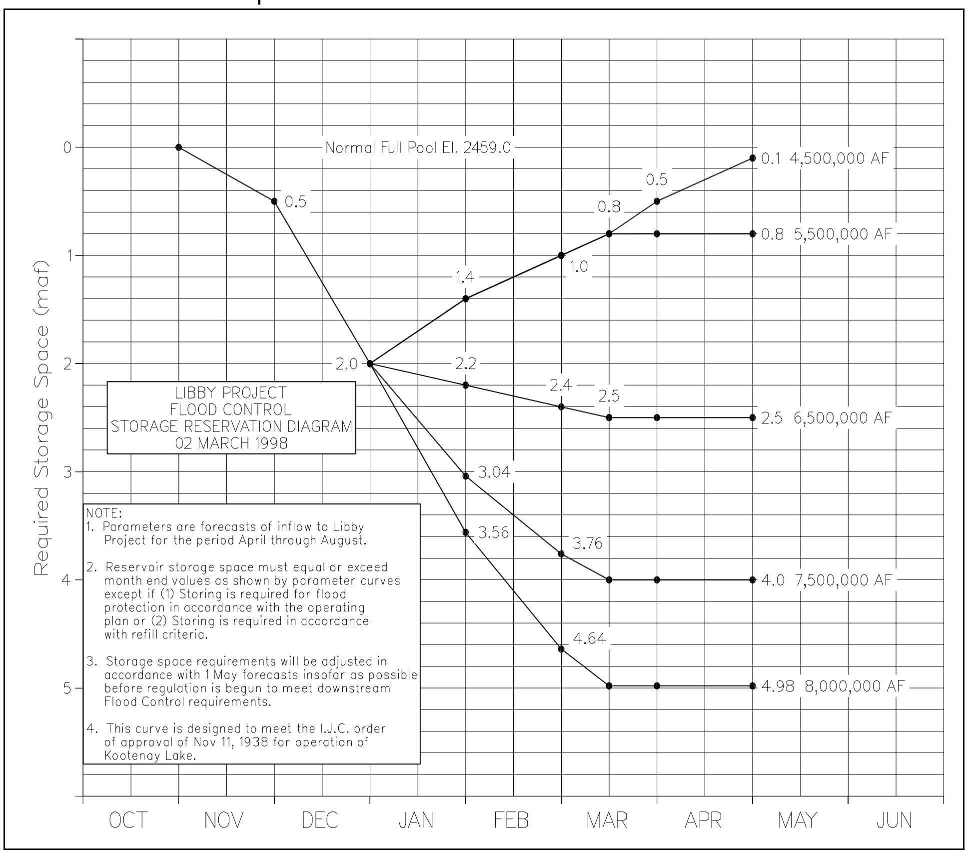

Figure 1. VARQ Storage Reservation Diagram for Libby Dam

Rule 2. Initiation of Refill. Initiation of refill is determined by the operating procedures for system flood control on the lower Columbia River. These procedures are described in *Columbia River Treaty, Flood Control Operating Plan, October 1972*. At Libby Dam, refill is initiated approximately ten days prior to when streamflow forecasts of unregulated flow are projected to exceed the Initial Controlled Flow (ICF) at The Dalles, Oregon. This criterion applies most of the time: however, if the reservoir intersects with its flood control refill curve (FCRC) prior to ICF being reached, then refill is initiated at that time. The FCRC is a refill curve that fills the reservoir with 95 percent confidence at minimum outflow.

Rule 3. Initial VARQ Outflow. Use the figure below to determine an initial VARQ outflow for Libby Dam.

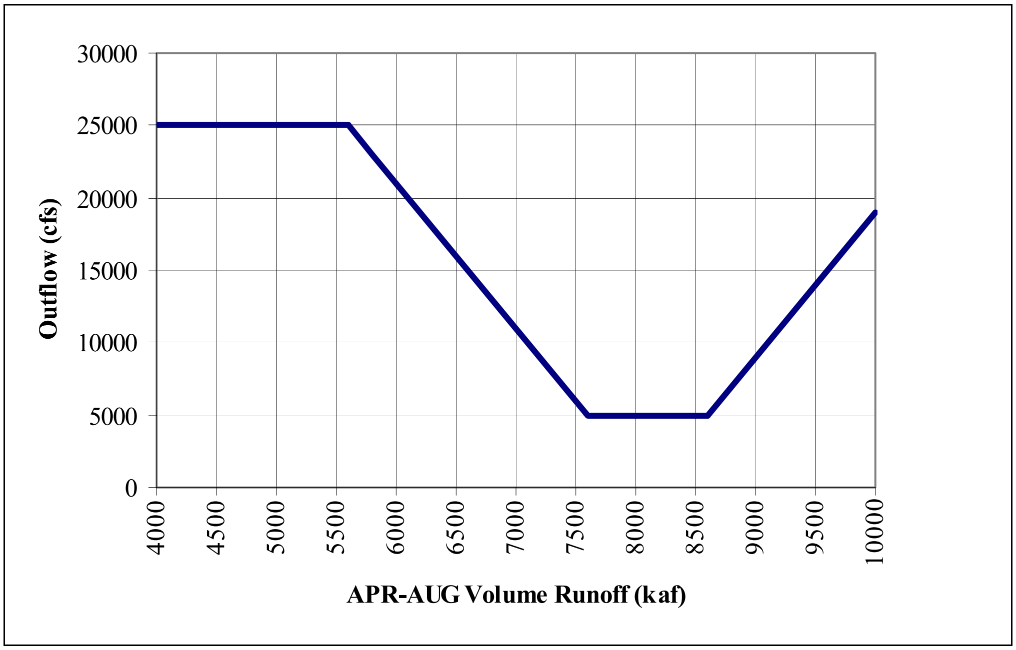

Figure 2. VARQ Outflows at Libby Dam

Rule 4. Adjusting VARQ Outflows for Delta Storage. Adjust the initial VARQ outflow, if necessary, to compensate for any storage difference between the actual reservoir level and the space required for flood control. This difference can reflect under or over-drafted conditions (Delta). This is done in the following manner:

- Estimate the duration of the system flood control operation (Duration) using the figure below. Select the appropriate curve based on the level of the latest projected control flow at The Dalles (ICF).

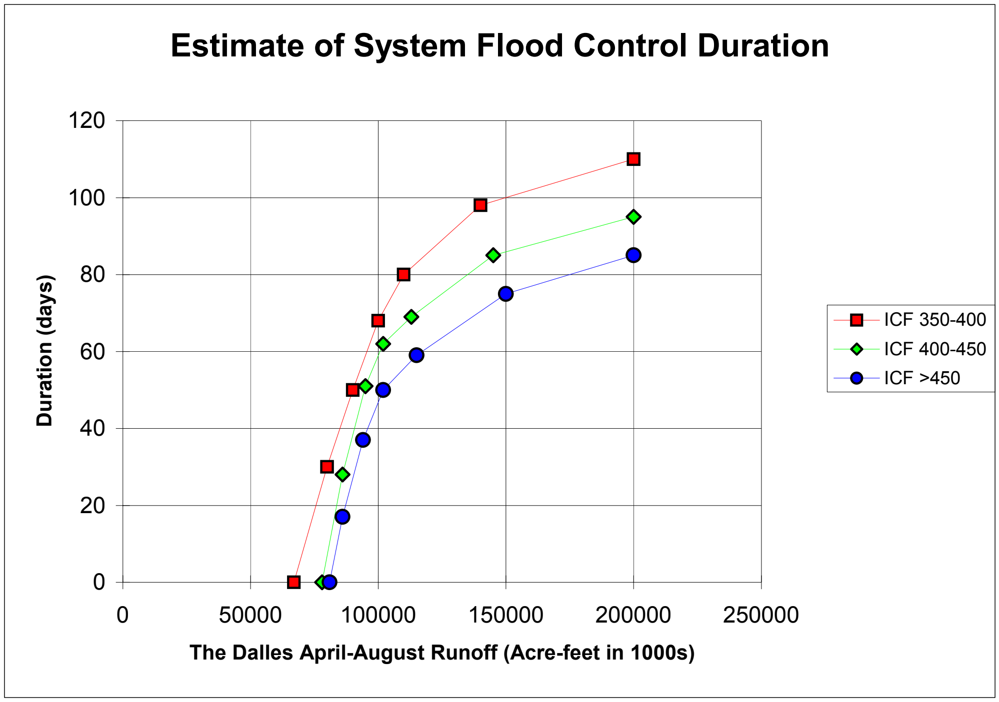

Figure 3. Estimate of System Flood Control Duration

- From the selected curve determine the flood control duration using the April-August runoff forecast for The Dalles.
- Compute the VARQ storage adjustment:
  ADJSTO = [Delta(kaf) x 0.5(ksfd/kaf)] / Duration(days)
- Compute the new VARQ outflow:
  VARQ(new) = VARQ(initial) + ADJSTO

If the runoff forecast at The Dalles is less than 85 million acre-feet, it is likely that system flood control of any significant duration will not be necessary for the lower Columbia River. Use streamflow forecasts to adjust VARQ outflows, if necessary, to compensate for any storage difference between the actual reservoir level and the space required for flood control. Reduce the VARQ outflows as necessary to provide protection against local flooding and to improve the likelihood of refill.

<u>Rule 5. Adjusting VARQ Outflows for Prior VARQ Releases.</u> VARQ releases are seasonal in nature, generated using seasonal runoff forecasts.

- This rule accounts for the difference in outflows released since the initiation of refill and the new VARQ outflows developed using the updated runoff forecast:

ADJDUR = [VARQ(new) – VARQ(prior)] x [Prior Release(days) / [New Duration(days) – Prior Release(days)]]

- Compute final VARQ outflow:
  VARQ(final) = VARQ(new) + ADJDUR

<u>Rule 6. Inflows Less than VARQ Outflows.</u> At the initiation of refill, if inflows are less than the VARQ outflow, pass inflow until inflows rise to the VARQ level. Thereafter, if inflows drop below the VARQ outflow, pass inflow until they rise again to the VARQ level.

Rule 7. Updating VARQ Outflows During Refill Season. Update VARQ outflows throughout the refill season as new runoff forecasts are developed. Use streamflow forecasts to evaluate the performance of the VARQ outflows in meeting system and local flood control objectives. Reduce VARQ outflows if necessary to provide protection from local flooding. Return to VARQ outflows once local flooding is over.

Rule 8. Final Stages of Refill. Increase outflows during the final stages of refill to avoid overfilling and unwanted spill. Likewise, decrease outflows during the final stages of refill if the present outflow would otherwise not fill the reservoir. Use streamflow forecasts and engineering judgment to select the appropriate outflows.

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